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University of Maryland
Department of Physics and Astronomy
College Park, Maryland

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Introduction

We are carrying out a search for gravitational waves. This kind of radiation was predicted by Einstein in 1916, from a study of the weak field solutions of the General Theory of Relativity. No one has yet observed gravitational waves, and thus far no rigorous proof of their existence has been given. However, considerable theoretical research during the past forty seven years has made it very plausible that such radiation exists.

Theoretical Research

Professor Misner and Dr. Zapolsky have been studying highly condensed and collapsed stars. Their properties and the processes by which they might be formed determine the frequency spectrum and abundance of gravitational radiation from the most intense source yet proposed, namely close binary collapsed stars. Some preparatory studies are going on for a study of the dynamics of the ultimate collapse in a more realistic idealization than that of Oppenheimer and Snyder. The most active current effort is an attempt to show that the non-existence of cold static equilibrium states for massive stars (which have exhausted their thermonuclear energy sources) is independent of the equation of state at densities much higher than nuclear density. Computations by Misner have already shown that the maximum baryon-baryon repulsive force allowable by relativity theory, if proposed to enter at high energies, will not help to produce equilibrium states for massive cold stars. Zapolsky is preparing a calculation with the opposite assumption, namely that the pressure of a baryon gas is extremely small at densities above those where reasonable estimates can be made. If both these extreme calculations suggest, as do intermediate assumptions in previous calculations by Oppenheimer and Volkov, Salpeter, and Ambartsumyan and Saakyan, that no stable alternative to eventual collapse is conceivable, they will proceed to studying: (1) properties of totally collapsed systems and (2) dynamics of collapse.

Experimental Research

Several years ago it was noted[1] that free oscillations of an elastic body might be excited by gravitational waves. The gravitational interaction is incredibly weak. A very large elastic body is needed to obtain good sensitivity, so it was suggested that the earth[1] and the moon[2] be employed. One way of detecting the free oscillations is to make use of a sensitive gravimeter. This detects small changes in acceleration due to gravity as the earth or lunar surface executes the free oscillations.

The earth's surface is quite noisy because the changes in barometric pressure, temperature and other weather effects have a somewhat random character. It is hoped that the lunar surface will be better.

Professors Weber and Zipoy and Mr. Kaup have been studying several kinds of gravimeters. Our immediate objective is to develop a gravimeter which is capable of being rocket landed on the lunar surface. We have been considering instruments of the La Coste Romberg type. These employ metal springs and a mass of about 100 grams. It is desirable to be able to sense the position of the mass, then to employ a closed loop servo system to restore the mass to its original position. The servo voltage required to do this then becomes a measure of the change in acceleration due to gravity. Existing methods of sensing the position of a mass make use of an optical lever to give relatively large displacements of a light beam as a mirror associated with the mass is tilted. We are exploring such methods as well as new methods which unbalance a radiofrequency bridge as the acceleration due to gravity changes. We are also studying superconducting gravimeters. These employ a superconducting mass suspended in a magnetic field.

Research During the Next Six Months

We anticipate that the theoretical research will be concerned with the dynamics of gravitational collapse and the emission spectrum of gravitational radiation. Our experimental research will endeavor to produce a preliminary model of a recording gravimeter.

1. J. Weber, Phys, Rev. 117, 306, (1960) and General Relativity and Gravitational Waves, Chapter 8, Interscience Publishers, 1961.

2. J. Weber, NASA (Stanford) Conference on Gravitation, 1961